THE EFFECT OF PHYSICAL THERAPY FOR CHILDREN WITH MOTOR DELAY AND CEREBRAL PALSY

A Randomized Clinical Trial[1]

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ABSTRACT Mayo NE: The effect of physical therapy for children with motor delay and cerebral palsy: a randomized clinical trial. *Am J Phys Med Rehabil* 1991;70:258–267.

Physical therapists recommend neurodevelopmental therapy for cerebral palsy, but its effectiveness has not been fully established. A randomized controlled trial was undertaken to compare the effects over 6 months, of weekly (intensive) and monthly (basic) neurodevelopmental therapy on the motor development of young children with suspected cerebral palsy. Subjects were no older than 18 months when referred for physical therapy because of a motor delay. All those meeting specified criteria were assessed on seven motor development tests: reflex activity, postural reactions, gross motor ability, fine motor skills, mental functioning, dominance of abnormal movement patterns and ability to participate in activities of daily living. The average proportional change in aggregate motor development for the 17 infants on the weekly (intensive) regimen was substantially better than that for the 12 on the monthly (basic) regimen, after adjusting for the child's age, whether the child was born at term or not, and mother's education. A statistical test led to an equivalent of a Student's $t = 3.49$, which with 24 *df* was associated with $P = 0.0019$ (two-sided).

KEY WORDS: Cerebral Palsy, Physical Therapy, Motor Development, Clinical Trial

The treatment of cerebral palsy relies mainly on physiotherapeutic modalities that are generally based on the principles of neurodevelopmental therapy (NDT) described in the 1960s by Bobath[2] and Bobath.[3] NDT aims not only at reducing the domination of abnormal movement patterns but also at encouraging normal purposeful movement. NDT is demanding both for the child and for the parent; it requires regular outpatient attendance for therapy, together with a program for the parents to carry out at home. Indeed, many parents are unable to comply fully, because it is stressful and time-consuming both to master the recommendations[1] and, once mastered, to maintain them.[4] Nevertheless, many therapists support the initiation of NDT as early and as intensively as possible. This enthusiasm has not been justified by evaluative research, and so many health professionals doubt that the benefits derived from therapy warrant the time and effort expended by parent and child.[1, 5–8]

A study of the effectiveness of NDT was undertaken to address some of the controversy surrounding the benefits of physical therapy for cerebral palsy. A randomized controlled trial was designed to compare the changes in development, over a 6-month period, of children receiving comparatively intensive physical therapy, i.e., weekly NDT, with similar children receiving more basic physical therapy, i.e., monthly NDT. The study examined the effectiveness of providing physical therapy services at two intensities under the usual circumstances that would be encountered if a child with delayed or abnormal motor development had been referred to a pediatric physical therapy department.

In the exploratory phase of this study,[9] the research design was tested, the feasibility and scoring of the instruments were examined and predictors of change investigated. The findings from this exploratory phase were used to refine the protocol for the main study. The report presented here deals only with the main study. (Full details on the exploratory phase can be found in Reference 9.)

METHODS

Subjects

All children under 2 yr of age with delayed or abnormal acquisition of motor behavior referred for the first time to the physical therapy department of Ste. Justine's Hospital, Montreal, Quebec, from September 1983 to September 1984 were considered for inclusion, provided they lived in an area accessible for regular visits to the hospital. subjects with additional chronic diseases, obvious profound mental retardation, a genetic disorder or a degenerative

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lesion of the central nervous system, proven intrauterine exposure to any viral or other infectious disease or a handicapped sibling were excluded, as were children who had previously or were currently receiving occupational therapy. A total of 58 children met these criteria, and the parents of 29 children agreed to have their child involved in the trial, which included randomized allocation into one of the two treatment groups; intensive or basic. For the most part, the children whose parents did not agree to participate in the study had mild motor delays and their parents were unwilling to be randomized into the group demanding weekly visits. The characteristics of the subjects included in the study are presented in Table 1.

The Intervention

The regimens for both the intensive and basic groups were based on principles of NDT, they were both to be maintained for 6 months and were to include an individually tailored basic home program to be revised as necessary. For both regimens, the home program was written out in a booklet and illustrated with Polaroid photographs of the child in the appropriate position. The booklets were designed as an aid to compliance; however, no specific measure was made of the degree to which the parents complied with the home programs.

The basic regimen consisted of monthly hospital visits, 1 h in duration, at which the parents received instructions for carrying out a home program. The home program consisted of suggestions for positioning, handling and stimulation. The parents were shown ways to position the child to participate in normal purposeful activity during feeding, dressing, bathing and playing.

The intensive regimen was similar to the basic regimen in the duration of the hospital visits and in the provision of the home program. It differed from the basic regimen in that the child attended weekly. The more intensive treatment provided the oppor-

TABLE 1

Description at initial evaluation and final diagnosis for subjects in the main trial

Gross Motor Ability	Age	Reason for Referral	Final Diagnosis
	mo		
	Severely delayed (unable to sit: gross motor ability ≤ 50)		
0	7	Hypertonicity, microcephaly	Cerebral palsy
8	12	Double hemiplegia	Cerebral palsy
10	4	Encephalopathy	Cerebral palsy
16	4	Aspiration, convulsions	Cerebral palsy
20	7	Double hemiplegia	Cerebral palsy
28	9	Hypertonicity, prematurity	Cerebral palsy
32	8	Hypertonicity, prematurity	Cerebral palsy
32	12	Encephalopathy	Cerebral palsy
46	8	Hypertonicity	Cerebral palsy
46	11	Motor delay, prematurity	Cerebral palsy
46	14	Microcephaly, motor delay	Cerebral palsy
48	8	Hypertonicity, microcephaly	Cerebral palsy
28	5	Hypotonia, torticolis	Unchanged
40	11	Cardiopathy, hypotonia	Motor delay
46	9	Hypertonicity, prematurity	Mild gait disorder
	Moderately delayed		
54	12	Hemiplegia	Cerebral palsy
62	18	Diplegia	Cerebral palsy
70	10	Motor delay, prematurity	Cerebral palsy
72	12	Encephalopathy	Cerebral palsy
76	14	Hemiplegia	Cerebral palsy
84	7	Asphyxia	Cerebral palsy
112	12	Hemiplegia	Cerebral palsy
116	16	Hemiplegia	Cerebral palsy
92	14	Motor delay	Unchanged
138	14	Encephalopathy	Mild gait disorder
138	14	Diplegia	Mild gait disorder
66	14	Hypotonia, motor delay	Normal
82	13	Motor delay, prematurity	Normal
116	13	Encephalopathy	Normal

tunity for the therapist to design and carry out special maneuvers to meet specific therapeutic goals.

Both the intensive and the basic regimens were carried out by the physical therapists assigned to treat the child. All therapists were either certified NDT therapists or had participated in formal training courses in NDT.

Instruments

Seven aspects of the motor development of a physically handicapped child were assessed (Table 2). A brief description of each instrument is given below; full details on the instruments are in Reference 9. Each instrument comprised a number of items; the achievement of each item was rated, sometimes simply pass or fail and sometimes with a gradation of competence. A score was assigned to each gradation of each item and these scores were combined into a measure, one for each instrument. The measures for each of the seven instruments were summed to create one aggregate index of motor development.

Of the seven instruments only two (Nos. 4 and 5) were known to be valid and reliable.[10, 11] The rest of the instruments were new or had never been evaluated for accuracy. Four of these untested instruments (Nos. 1, 2, 3 and 6) underwent extensive scrutiny as part of the exploratory phase; this included devising scores and measures and testing interrater reliability. The full details of the interrater trial and of the development and scoring of the instruments appear elsewhere.[9] The last instrument (No. 7) assessed parents' perceptions, the accuracy of which could not be tested.

Primitive Reflexes

Four reflexes (the asymmetrical tonic neck reflex, the tonic labyrinthine reflex, positive support and the Moro reflex) were assessed according to the procedure outline by Capute et al.[12–14] Each reflex was scored on a five-point scale: the lowest category (scored 0) indicated no reflex activity and the highest category (scored 4) indicated obligatory reflex activity. Adding the separate scores for the four reflexes provided a numerical measure of reflex activity, which thus could range from 0 to 16. (For the purposes of analysis these scores were reversed.) The results from the interrater agreement trial that was carried out during the exploratory phase before this study (see Ref. 9) revealed a high degree of consistency in the scoring of this instrument (Kendall's coefficient of concordance = 0.94).

Postural Reactions

The degree of development of postural reactions was adapted from the instrument described by Bobath and Bobath.[15] Twelve items (four righting reactions, four equilibrium reactions and four protective reactions) were evaluated, each as: absent (scored 0), present and effective (scored 2, 4, 8, according to item) or present but ineffective (scored intermediately). The scoring system developed[9] for these gradations varied among the 12 items; the measure was taken as the sum of the item scores, and it could vary between 0 (reaction absent on all 12 items) and 96 (all reactions present and effective). The results from the interrater agreement trial[9] revealed a high degree of consistency in the scoring of this instrument (Kendall's coefficient of concordance = 0.88).

Gross Motor Ability

Gross motor ability was assessed by the Wolanski Gross Motor Evaluation,[16] which incorporates a total of 34 motor skills in four developmental sequences: head and trunk control (6 items), sitting (9 items), standing (9 items) and locomotion (10 items). The original scores proposed by Wolanski and Zdanska-Brincken[16] were inappropriate for use with this handicapped population as they reflected the motor development of normal infants. Each item was therefore assigned a new score based on the relevance of achieving success on the item for a child with a motor handicap. For example, the item assessing ability to bear weight on lower extremities is weighted heavily in the original scoring (i.e., 41 points). Children with spasticity may invoke extensor tone to achieve this item, and thus it was given a lower weight in the new scoring system (2 points).

TABLE 2
Instruments for assessing motor development

Instrument	Number of Elements	Gradation[a]	Measure
1. Reflex activity	4	0–4	0–16
2. Postural reactions	12	0, 1, 2	0–96
3. Gross motor ability	34	0, 1	0–180
4. Fine motor skills	28	0, 1	0–28
5. Bayley (Mental) scale	181	0, 1	0–181
6. Abnormal movement scale	21	0, 1, 2	0–186
7. Activities of daily living	3	0–4	0–12
Aggregate index	283		0–699

Note: full details on these instruments can be found in the original references (i.e., Refs. 10–16) and by consulting Reference 9.
[a] 0 = fail.

A measure for this instrument (ranging from 0–180) was obtained by summing the new scores over the 34 items. A high degree of consistency in the scoring of this instrument was achieved during the interrater agreement trial (Kendall's coefficient of concordance = 0.96).

Fine Motor Skills

The choice of fine motor skills was based on the work of Gesell and Amatruda.[10] The 28 find motor skills from their developmental screening inventory were included; the measure we used was a count of the number of fine motor skills the child was able to master.

Bayley (Mental) Scale of Infant Development

The Bayley Scale[11] is generally considered an ideal instrument for assessing infants with motor handicaps as many of the items grade, as a positive response, the anticipation or the desire to perform a motor activity rather than demanding a specific motor action. The developmental quotient usually used was inapplicable for assessing change in a physically handicapped child. Instead, the measure for this instrument was taken simply as the count of the number of items passed.

The Abnormal Movement Scale

An instrument to assess the abnormal movement patterns typical of a child with a neuromotor deficit was developed especially for this trial. The degree of control the child exhibited over 11 typical abnormal movement patterns was assessed as: poor (scored 0), good (scored from 2–16 according to item) or intermediate (scored intermediately). One movement pattern applied to the control over the trunk; the other 10 to the motor control of the limbs and, thus, each was evaluated on both the upper and lower extremities. The scoring system developed[9] for these gradations varied among the 21 items; the measure was taken as the sum of the item scores and could vary between 0 (poor control on all 21 items) and 186 (good control on all items). A high degree of consistency in the scoring of this instrument was achieved during the interrater agreement trial (Kendall's coefficient of concordance = 0.96).

Activities of Daily Living

Parents' perceived difficulties in feeding (both solids and liquids) and dressing their child were each assessed on a five-point scale: difficult (scored 0), passive (1), assisting (2), partially independent (3) and independent (4). The measure for activities of daily living was obtained by adding the scores for feeding solids, feeding liquids and dressing and, thus, could range from 0–12.

The Variables

The three types of variables under examination in this study were exposure, outcome and confounding variables. There was only one exposure variable, the intensity of the regimen, i.e., weekly or monthly visits. The outcome variable was percent of proportional change in motor development calculated according to the formula given below:

$$\frac{100\ (\text{final aggregate index} - \text{initial aggregate index})}{(\text{final aggregate index} + \text{initial aggregate index})/2}$$

This estimator of proportional change was chosen as we felt it was important to minimize regression to the mean thereby reducing the effect that the initial score has on change.[17,18] An additional advantage of this estimator is that it reduces problems over correlated errors that arise if proportional change is estimated from the difference between final and initial levels divided by the initial.

The confounders were those variables identified during the exploratory phase of the study as important predictors of change in motor development. The variables investigated as possible predictors of change are listed in Table 3. Only those footnoted variables were identified as being significantly associated with change in motor development, i.e., age of the child at initial evaluation, term or preterm birth and mother's level of education.

Procedure

Each child had their motor development assessed on entry into the study by two evaluators extensively trained in the use of the instruments; a psychologist assessed the children using the Bayley Scale, while a physical therapist administered the other six instruments. Subjects with initial gross motor ability <50 (i.e., unable to sit) out of a possible score of 180 (see Table 1) were classified as severely delayed; those with higher scores of gross motor ability were classified as moderately delayed.

Within these two classes, subjects were randomly assigned to one of two regimens of physical therapy; intensive or basic. The allotted regimen was revealed only to the treating therapist, who made arrangements for therapy to start and to continue at the intensity indicated.

After 6 months of therapy, each subject was reevaluated by the same two initial evaluators, who did not know to which regimen the subject had been assigned nor did they have access to any of the initial assessments.

Statistical Methods

To eliminate the possibility of finding a false association by examining each of the seven instruments as though it were independent, a regression

TABLE 3
Baseline characteristics of the subjects and families[a]

	Treatment Group	
	Intensive (17 Subjects)	Basic (12 Subjects)
Characteristics of the child at referral		
No. of severely delayed infants	9	6
Mean age (months)[b]	11.4 (3.8)	9.9 (3.2)
Mean IQ	89.6 (26.0)	87.3 (27.4)
Mean weight: percentile[c]	28.8 (29.9)	18.1 (20.3)
Characteristics of the perinatal period		
No. of infants born at term[b]	12	5
No. with birthweight <1500 g	2	2
No. by Cesarian section	8	5
No. intubated	2	4
No. transfused	1	3
Mean Apgar score at 1 min	6.9 (1.9)	5.8 (2.4)
Mean Apgar score at 5 min	8.1 (2.3)	7.7 (1.9)
Mean duration of stay (days)	14.8 (14.4)	17.6 (18.0)
Characteristics of the mother and family		
No. of first born infants	8	6
No. of mothers with only high school[b]	13	5
No. of mothers working	7	6
No. of families with income		
<10,000	4	2
>$30,000	2	5

[a] Figures in parentheses are standard deviations.
[b] Variables included as covariates.
[c] Percentile for weight.

analysis[18] was used in which percent of proportional change in motor development was the regressor variable and the predictor (denoted by a dummy variable) was the regimen. Age of the child at initial evaluation, term or preterm birth and mother's education were the only variables included as covariates. The estimated regression coefficient for intensity of treatment when related to its standard error yields the equivalent of a t statistic.[19]

Statistical testing of the association between intensity and treatment and percent of proportional change for each of the outcome measures was not feasible. Had a test been carried out, it would have had to be subjected to a Bonferroni correction (multiplying each P value by the total number of endpoints, see Ref. 20).

RESULTS

The Subjects

Table 1 describes the 29 subjects participating in the main trial according to gross motor ability at initial evaluation, giving age, the reason for referral and their diagnosis by the end of the trial. The final diagnosis of 20 of the 29 subjects (69%) was cerebral palsy, six subjects had other nonspecific motor delays and three were normal. The eventual group assignment of each child is also presented.

Table 3 presents information on the baseline characteristics of the children and their mothers. The footnoted variables were those which analysis of the material from the exploratory phase suggested was important to include as covariates.

Changes in Motor Development

Figure 1 gives the initial and final aggregate indexes of motor development for each subject. Each line has an "o" indicating the subject's initial aggregate index, and one of the "cp," "od" or "n" indicating whether the final diagnosis of the subject was cerebral palsy, other diagnosis or normal. The subjects have been ranked by their initial gross motor ability and the intensity of therapy is indicated by the solidity of the line.

Table 4 presents the mean values of the initial and final aggregate index. Table 5 gives the mean difference between the two aggregate indexes and the mean value of percent of proportional change. In Table 6, the covariates are listed with the units and the regression coefficients. To obtain the adjusted outcome as given in Table 5, the estimate of percent of proportional change in motor development for each subject was adjusted by subtracting from it the total of the cross products of each covariate and its regression coefficient (see formula in Appendix 1). The estimated regression coefficient for intensity of treatment (36.7; see last line of Table 6) is equivalent to the difference between the mean

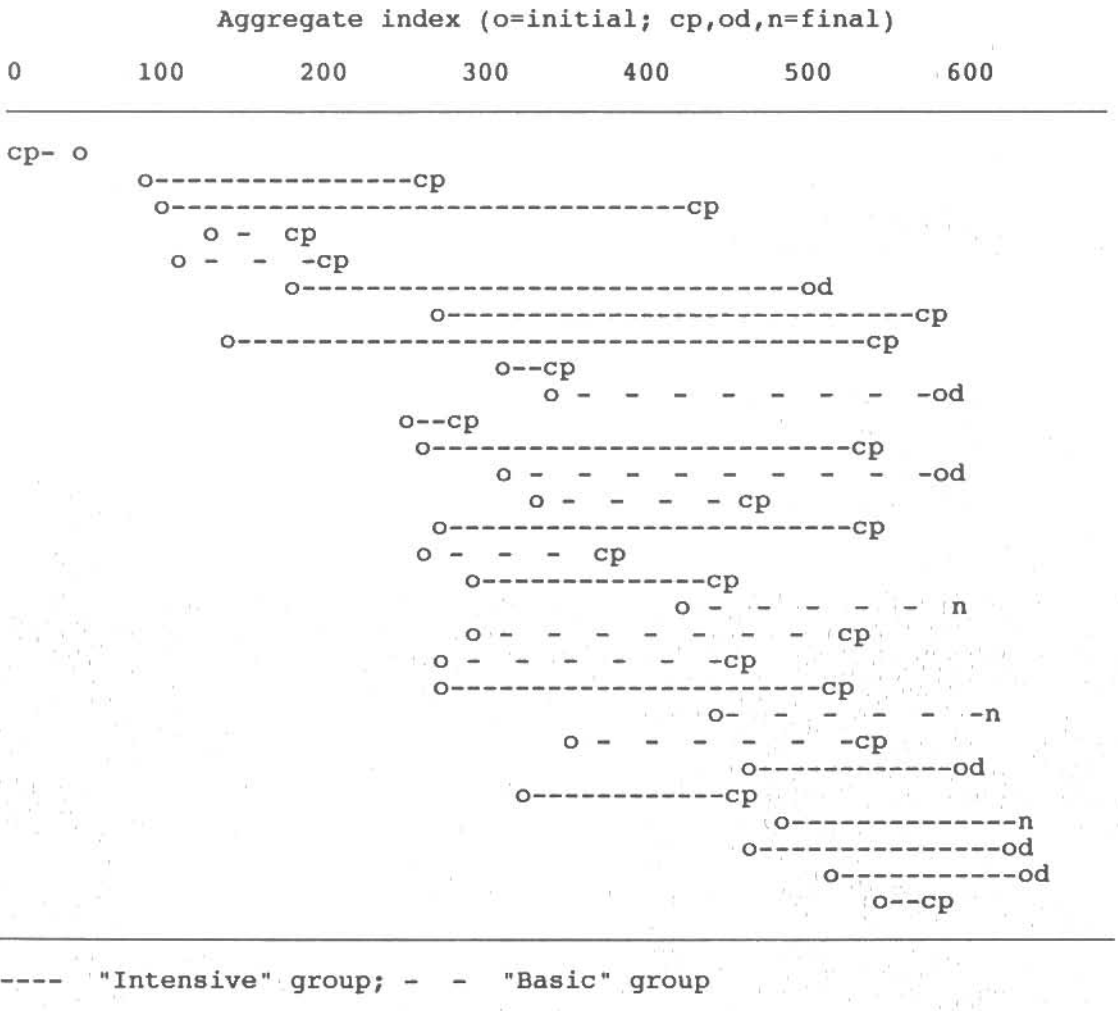

Figure 1. Initial and final aggregate indexes for each subject.

TABLE 4
Mean initial measures on each instrument[a]

Instrument	Treatment Group: Intensive (17 Subjects)		Basic (12 Subjects)	
Primitive reflexes	10.4	(4.2)	10.5	(3.8)
Postural reactions	28.1	(19.7)	32.0	(19.8)
Gross motor ability	64.4	(45.8)	56.7	(37.2)
Fine motor skills	9.8	(5.1)	10.0	(4.8)
Bayley (Mental) scale	97.6	(19.1)	87.3	(28.0)
Abnormal movement scale	75.8	(49.9)	86.1	(52.8)
Activities of daily living	6.9	(2.4)	6.0	(2.5)
Aggregate index	292.9	(129.6)	288.6	(137.4)

[a] Figures in parentheses are standard deviations.

TABLE 5
Comparison of mean initial and final aggregate indexes of motor development of the two treatment groups[a]

Aggregate Index	Treatment Group: Intensive (17 Subjects)	Basic (12 Subjects)
Initial	292.9 (129.6)	288.6 (137.4)
Final	466.3 (118.3)	448.1 (198.9)
Difference between final and initial	173.4 (99.4)	159.5 (82.3)
Percent proportional change	50.2 (33.1)	38.0 (30.7)
Adjusted outcome[b]	92.0 (19.0)	55.3 (27.0)

[a] Figures in parentheses are standard deviations.
[b] Percent proportional change adjusted for age, mother's education and term or preterm birth (see text, Table 6 and Appendix 1).

adjusted outcome of the intensive group and the mean adjusted outcome of the basic group and, when related to its standard error (10.5), yielded a t statistic of 3.49 (24 df; $P = 0.0019$).

To see whether the treatment effect was attributed to only one or a few instruments, the effect of intensity of therapy was examined separately for each of the seven instruments (Table 7). On all seven instruments, the "intensive" group performed, on average, higher than the "basic" group; however, statistical testing of the seven instruments separately would be inappropriate due to the necessity of applying a Bonferroni correction (see Methods and Reference 20).

Four subjects were unable to comply with the conditions of the trial and did not complete the prescribed regimen. Two had been assigned to the basic group but, when their progress was judged to be insufficient, received weekly sessions; the other two had been assigned to the intensive group, yet received virtually no therapy. Once allocated to one of the groups, no subject was excluded from the analysis that was carried out respecting the original randomization. If these subjects had been eliminated from the analysis a slightly greater difference in adjusted outcome would have resulted; however, because of fewer degrees of freedom, the t statistic would have been smaller. Correspondingly, excluding independently the nine subjects, whose final condition was not cerebral palsy, would also have resulted in a greater difference in adjusted outcome but a smaller t statistic.

TABLE 6
Units and regression parameters for the variables included in the regression analysis

Variable	Regression Coefficient	Standard Error
Covariates		
Age (mo)	−5.5	1.3
Mothers' education 1: high school 0: no high school	26.2	9.9
Term or preterm birth 1: term birth 0: preterm birth	−25.5	9.6
Predictor variable		
Intensity 1: intensive 0: basic	36.7	10.5

DISCUSSION

The principal finding of this trial was that the group treated intensively responded considerably better, on average, than the group treated only with the basic regimen, taking into account the effects of the child's age, the mother's education and whether the child was born at term or earlier. Even though this was a randomized trial, the effect of these variables had to be considered because of their importance as prognostic variables and because randomization cannot be relied on, even in very large samples, to balance the groups on all variables. Indeed, the groups were quite dissimilar with respect to these variables. The intensive group had 13 mothers with only a high school education (compared with 5 in the basic group), had a higher proportion of infants born at term and was slightly older on average. The effect of the imbalance on these three variables placed the intensive group at a disadvantage in comparison with the basic group because mothers without higher education are likely to be less able to participate in the child's program, because the type of birth injury sustained by a term infant is different from that of a preterm infant and is often associated with more severe handicap[21] and because many feel that the longer therapy is delayed the poorer will be its outcome.

The effect of intensity was observed even with the small number of subjects in this study. Originally only one trial had been planned with a much larger sample size; however, adjustments had to be made to the protocol, necessitating the separation of the exploratory phase from the main trial. Thus, statistical power was lost for internal validity.

In this study, the regimen of intensive NDT was superior to the basic regimen of a home program in affecting change in the motor development of the

TABLE 7
Regression parameters for intensity of treatment assessed for each individual instrument

Instrument	Regression Coefficient[a]	Standard Error	Regression Coefficient/ Standard Error
Primitive reflexes	31.3	16.8	1.86
Postural reactions	50.6	17.8	2.84
Gross motor ability	19.9	13.6	1.46
Fine motor skills	15.7	14.3	1.10
Bayley (Mental) scale	13.8	8.5	1.62
Abnormal movement scale	57.6	19.8	2.91
Activities of daily living	42.0	27.3	1.54

[a] Each adjusted for age, mother's education and term or preterm birth.

children who were studied. Two early investigations[7,8] had not found NDT effective in changing motor development; however, both had methodologic flaws including variable or undefined length of treatment time, which makes it difficult to draw firm conclusions. Additionally, it was doubtful whether the instruments used were sensitive enough to detect change in motor development. A later study, published after this work was completed,[22] demonstrated that a physical therapy program was no more effective in improving motor development for children with cerebral palsy than an infant-stimulation program. Two studies[23,24] on the effects of NDT for infants discharged from neonatal intensive care units failed to demonstrate the superiority of this intervention. Thus, this is one of the few studies to show a positive finding. The study was designed to achieve high internal validity, an there is no reason to believe that the results cannot also be generalized.

Because improvement was based on a composite of seven measures assessing a wide spectrum of motor behavior, the gains in each specific skill were not enumerated. We did not choose to evaluate, for example, how many children could now sit, walk, manipulate an object, etc. as the indicators of improvement differ from child to child and therapy aims to improve function in as many areas as possible within the limitations of the handicap. Rather, the measurement system was designed to assess change in overall development. Although it is not possible to draw conclusions from the analysis of the seven instruments separately, it was of interest that the impact of intensive therapy was not concentrated in any one instrument.

This was a study of the effectiveness of two intensities of physical therapy in improving the motor development of children with motor delay including cerebral palsy. This was not a study of the efficacy of therapy. Efficacy would be difficult to ascertain in a clinical setting (as opposed to a laboratory setting) where compliance cannot be assured and the treatment regimens cannot be dictated. Indeed, four subjects did not attend the hospital visits as prescribed; however, in order not to break the random process by which children were assigned to regimens, these children were considered in the analysis as if they attended at their prescribed frequency. Dropping these subjects would have resulted in a biased estimate of effectiveness as obviously for those subjects the regimen to which they were assigned was ineffective.[25]

Although both groups were given a home program, it is possible that attending intensive therapy may have served as a reminder for the parents to carry out the prescribed activities and that this increased level of compliance contributed to the improvement in motor development. As the home program did not consist of a set of exercises to be done at a specified frequency but rather was based on recommendations on positioning and handling to be incorporated into the child's daily routine, measuring compliance to the home program would have been difficult.[4] Indeed, such an assessment could have been a research question on its own. Thus, this study did not attempt to measure the degree to which parents complied with the home program, and this remains a limitation of the study. Regardless of whether the improved motor outcome was mediated through the therapy or through enhanced compliance, or both, the conclusion remains the same—recommend more intensive treatment.

This study was designed to address the relative benefits of two regimens of therapy (intensive or weekly *v* basic or monthly) under the usual circumstances that would be encountered if a child was referred to the physical therapy department of a pediatric hospital. Thus, we chose not to rigidly control the treatment protocol as it is usual for therapists to tailor treatment programs to the needs of each child. We also chose to use the staff members of the physiotherapy department to treat the children rather than using specially recruited research therapists. We could not wait until a firm diagnosis of cerebral palsy was made before starting therapy as it is often difficult to make a diagnosis of cerebral palsy before 2 yr of age. Thus, we included some children whose final diagnosis was not cerebral palsy.[25] Indeed, three children evolved normally although they had presented earlier with a severe enough motor delay to warrant referral to physical therapy. The question of the effectiveness of referral for intensive or basic treatment was just as important for these children as for any other child presenting with an important motor delay.

CONCLUSION

This study shows that children with motor delay including cerebral palsy achieved greater benefit from referral for intensive weekly physical therapy than from referral for a basic home program with monthly revisions. This trial attempted to answer only one of the many questions that could have been asked about the effects of NDT. The results of this study should encourage therapists and families to continue to argue for the availability of intensive therapy for children with motor deficits.

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APPENDIX 1

Changes in motor development before and after adjustment

Unadjusted Proportional Change (Y_i)		Age	Mothers' Education	Term or Preterm Birth	Adjusted Outcome[a] $E(Y)$	
		Regression Coefficients (β)				
Intensive	Basic	−5.52	26.23	−25.51	Intensive	Basic
	−51.4	7	0	1		−20.0[a]
83.0		12	0	1	142.0	
117.7		4	1	1	106.3	
	48.1	4	1	1		36.8
	60.2	7	1	1		65.4
94.1		5	0	1	114.5	
72.4		9	0	0	89.3	
94.6		8	0	0	106.1	
6.7		12	0	1	65.7	
	52.7	11	1	0		54.5
16.1		14	0	1	86.1	
63.9		8	0	0	75.3	
	61.3	9	0	0		78.3
	30.9	11	0	0		58.9
56.1		8	0	1	93.0	
34.9		12	0	0	68.4	
42.5		18	1	0	82.8	
	37.7	14	1	1		81.5
	56.9	10	1	0		53.1
	56.6	12	1	0		63.9
51.6		14	1	1	95.4	
	35.6	13	1	0		48.4
	43.5	7	0	1		74.9
23.0		14	1	1	66.8	
38.3		12	0	1	97.3	
25.7		13	0	1	90.3	
	23.4	14	0	0		68.0
26.6		14	0	1	96.6	
6.3		16	0	1	87.4	
50.2	38.0		Mean		92.0	55.3
(33.1)[b]	(30.7)				(19.0)	(27.0)

[a] Calculated from the least squares regression formula: $-E(Y) = Y_i - [\hat{A} + \beta(\text{age}) + \beta(\text{education}) + \beta(\text{term birth})]$ where $\hat{A}$ is the intercept set at 32.7. For subject 1: $-51.4 - [(32.7) + (-5.52)7 + (26.23)0 + (-25.51)1] = -20$.

[b] Values in parentheses are standard deviations.

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